2.0 SYNOPSIS OF THE SCOS97-NARSTO FIELD MEASUREMENT PROGRAM

2.1 Study Scope

There are seven air basins in the SCOS97 domain (shown in Figure 2-1): the San Joaquin Valley (southern part of Kern County only), South Central Coast (Ventura County, Santa Barbara County and southern portion of San Luis Obispo County), South Coast, San Diego, and Mojave Desert and Southeast Desert Air Basins (abbreviated SJVAB, SCCAB, SoCAB, SDAB, and SEDAB, respectively). The study area includes about 53,000 square miles in the southern portion of the State, with a population of more than 18 million. Seven percent of the entire U.S. population, and more than half the population of California, live in the South Coast Air Basin alone. This region of California is an area of complex terrain (see Figure 2-2) — bounded by the Pacific Ocean to the west; to the north by narrow coastal mountains and valleys, the San Joaquin Valley, and the Sierra Nevada Mountains; and to the south and east by the California state border. Although the air basin boundaries were established with topographical features in mind, winds can and do transport pollutants from one basin to another.

The study dates were June 16 to October 15, 1997. The measurements to be made each day throughout the four-month study period included:

- Activity data for freeway traffic, major point sources, commercial and naval ships, commercial aircraft, and wildfires;
- Vertical profiles of winds and temperature from radar wind profilers with radio acoustic sounding systems (RWP/RASS) or SODARs at 32 sites;
- Vertical profiles of winds, temperature, and humidity from rawinsondes 1 or 2 times per day at 4 to 8 sites (depending on the day of the week);
- Speciated volatile organic compound (VOC) sampling every third day (2, 4, or 8 times a day) at 11 sites, and daily analysis 8 times a day at Burbank and Pico Rivera;
- Total reactive nitrogen (NO_y) at 14 sites and nitric acid (by difference) at 10 of those sites;
- Ozone and meteorology at 31 supplemental sites;
- Ozone, total nitrogen oxides (NO_X), and meteorology at 96 existing Air District sites;
- Surface meteorology at over 200 existing sites;
- Specialty radiation at Mt. Wilson and UC Riverside; and
- Total solar radiation at 78 existing sites.

During the month of September, additional continuous measurements include:

- Vertical profiles of ozone, aerosol extinction, temperature, and humidity from a lidar at Hesperia;
- Speciated VOC analysis 24 times a day at Azusa; and
- Hydroxyl and hydroperoxyl radicals, speciated VOC analysis, ozone, NO_X, CO, aerosol size, and ultraviolet radiation at UC Riverside.

Measurements to be made only during IOPs include:

- Vertical profiles of winds, temperature, and humidity from rawinsondes 4 times per day at 11 sites;
- Vertical profiles of ozone and aerosol extinction from a lidar at El Monte Airport;

- Air quality and meteorology aloft from 4 full-time and 2 part-time aircraft;
- Vertical profiles of ozone, temperature, and humidity from ozonesondes 4 times per day at 7 sites;
- Speciated VOC sampling at 25 sites, and aboard 4 aircraft;
- Halocarbons at 6 sites;
- Biogenic hydrocarbon and methylnitronapthalene sampling at 3 sites;
- Specialty nitrogen and VOC at Azusa;
- Peroxyacetyl nitrate (PAN) at 4 sites with peroxypropyl nitrate (PPN) at 2 of the sites; and
- Real-time single particle size and chemical composition at 3 sites.

Three additional studies are being conducted in coordination with the main SCOS97-NARSTO study described above:

- Aerosol program to be conducted between August 16 and September 14. It includes surface street traffic counts at 12 sites, state-of-the-art particle measurements at 3 sites, and a specially instrumented airplane along two separate air trajectories in the SoCAB (see Appendix A for a more complete description).

- Additional specialty radiation measurements at Mt. Wilson and UC Riverside during June 29 to July 5 and the first IOP between September 2 and 12.

- Tracer study with off-shore releases of 5 different perfluorocarbons during four 2-day periods between August 15 and October 15.

2.2 Study Area Climatology

Given the primary emissions within the complex terrain of southern California, it is the climate of southern California that fosters generation of ozone, a secondary pollutant. High ozone concentrations most frequently occur during the "ozone season," spanning late spring, summer, and early fall when sunlight is most abundant. Meteorology is the dominant factor controlling the change in ozone air quality from one day to the next. Synoptic and mesoscale meteorological features govern the transport of emissions between sources and receptors, affecting the dilution and dispersion of pollutants during transport and the time available during which pollutants can react with one another to form ozone. These features are important to transport studies and modeling efforts owing to their influence on reactive components and ozone formation and deposition..

Southern California is in the semi-permanent high pressure zone of the eastern Pacific. During summer, average temperatures are ~25 °C, with maximum daily readings often exceeding 35 °C. Precipitation events are rare. Frequent and persistent temperature inversions are caused by subsidence of descending air which warms when it is compressed over cool, moist marine air. These inversions often occur during periods of maximum solar radiation which create daytime mixed layers of ~1,000 m thickness, though the top of this layer can be lower during extreme ozone episodes (Blumenthal *et al.*, 1978). Relative humidity depends on the origin of the air mass, proximity to the coast, altitude, and the time of day, and can exceed 50 percent during daytime throughout the SoCAB with the intrusion of a deep marine layer. Relative humidity is higher near the coast than farther inland (Smith *et al.*, 1984a).

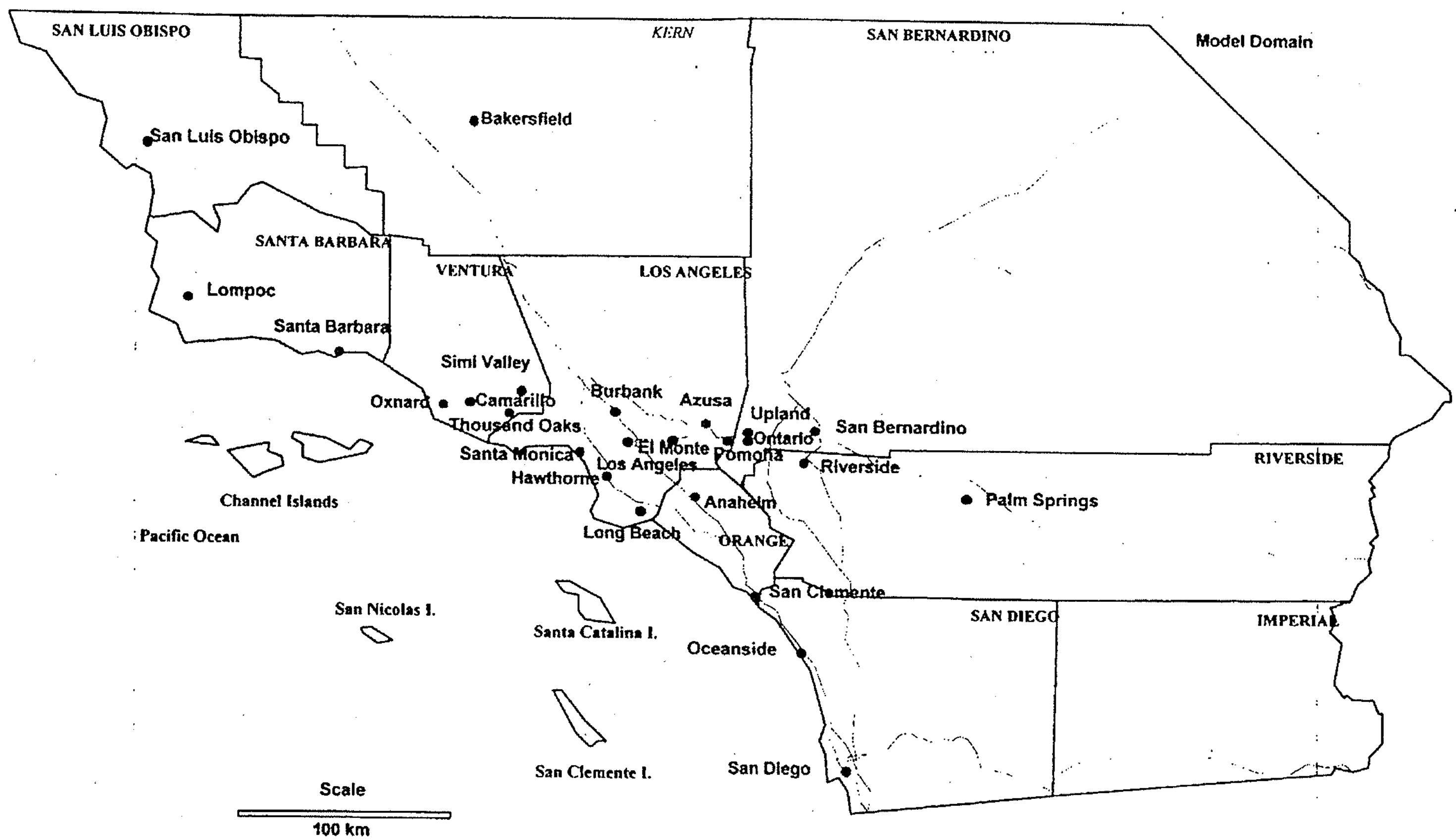

Figure 2-1. The SCOS97-NARSTO study area. Major cities, county boundaries, interstate highways, and the proposed modeling domain are shown.

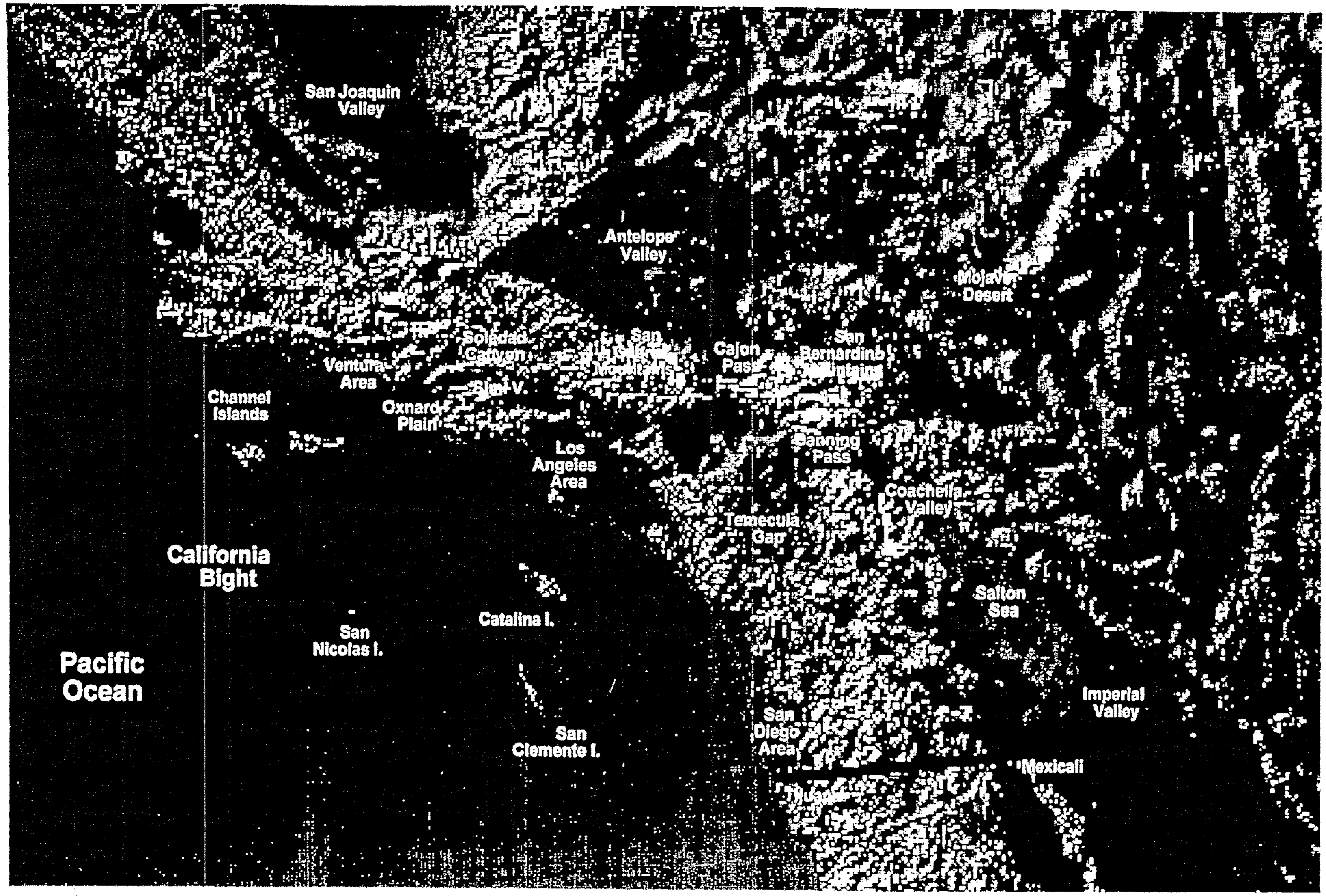

Figure 2-2. Topography of the SCOS97 study area.

Several experiments and data analysis studies examined the relationship of meteorology to air pollutant transport pathways, diffusion, vertical mixing, and chemical transformation in the SoCAB (e.g., Edinger, 1959, 1973; Edinger and Helvey, 1961; Pack and Angell, 1963; Kauper and Hopper, 1965; Schuck *et al.*, 1966; Estoque, 1968; Lea, 1968; Stephens, 1968, 1969; Miller and Ahrens, 1970; Edinger *et al.*, 1972; Rosenthal, 1972; Shettle, 1972; Smith *et al.*, 1972, 1976, 1984; Drivas and Shair, 1974; Angell *et al.*, 1975, 1976; Kauper and Niemann, 1975, 1977; Husar *et al.*, 1977; Keith and Selik, 1977; Blumenthal *et al.*, 1978; McRae *et al.*, 1981; Witz and Moore, 1981; Farber *et al.*, 1982a, 1982b; McElroy *et al.*, 1982; Reible *et al.*, 1982; Sackinger *et al.*, 1982; Schultz and Warner, 1982; Shair *et al.*, 1982; Witz *et al.*, 1982; Smith and Shair, 1983; Cass and Shair, 1984; Smith and Edinger, 1984; Zeldin *et al.*, 1989; Douglas *et al.*, 1991; Bigler-Engler and Brown, 1995;Lea *et al.*, 1995). These experiments and others reveal several general features.

Smith *et al.* (1972), Keith and Selik (1977), and Hayes *et al.* (1984) describe wind flow patterns in the SoCAB. During summer, the sea-land breeze is strong during the day with a weak land-sea breeze at night. Owing to the high summer temperatures and extensive urbanization in the SoCAB, the land surface temperature does not usually fall below the water temperature at night, and nocturnal and morning winds are less vigorous than daytime winds. The land surface cools sufficiently to create surface inversions with depths as shallow as ~50 m. Surface heating usually erodes the surface and marine layers within a few hours after sunrise each day. Summertime flow patterns are from the west and south during the morning, switching to predominantly westerly winds by the afternoon. The land/sea breeze circulation moves air back and forth between the SoCAB and the Pacific Ocean, as well as along the coast to other air basins. Cass and Shair (1984) estimated that up to 50 percent of the sulfate measured at Lennox was due to emissions which had been transported to sea on the previous day. When wind speeds are low, air tends to slosh back and forth within the SoCAB.

In addition to these general features, there are many smaller features that affect the movement of pollutants within the SoCAB. Heating of the San Gabriel and San Bernardino Mountains during the daytime engenders upslope flows that can transport pollutants from the surface into the upper parts of, and sometimes above, the mixed layer. When the slopes cool after sunset, the denser air flows back into the SoCAB with pollutants entrained in it. Convergence zones occur where terrain and pressure gradients direct wind flow in opposite directions, resulting in an upwelling of air. Smith *et al.* (1984) have identified convergence zones at Elsinore (McElroy *et al.*, 1982; Smith and Edinger, 1984), the San Fernando Valley (Edinger and Helvey, 1961), El Mirage, the Coachella Valley, and Ventura. Rosenthal (1972) and Mass and Albright (1989) identified a Catalina Eddy, a counterclockwise mesoscale circulation within the Southern California Bight, as a mechanism for transporting air pollution. This eddy circulation transports pollutants from the SoCAB to Ventura, especially after the SoCAB ozone levels drop due to wind ventilation caused by an approaching low-pressure trough from the northwest. However, any southeast wind in southern California is initially capable of transporting polluted air consisting of ozone precursors and particulate matter from the SoCAB.

General meteorological conditions and trajectories during the 1987 SCAQS episodes have been examined by Douglas *et al.* (1991). Flows during the summertime were westerly, and residence times were often less than 12 hours. The backward trajectories from Claremont and Riverside on August 27 and 28, 1987 show an upper level recirculation in the middle of the SoCAB that probably led to the build-up of ozone and precursors during this episode. Trajectories during SCAQS episodes were consistent with stagnation conditions desired for selecting episodes, and they provide confidence that the SCAQS forecasting methods can be successfully adapted to SCOS97 to evaluate high ozone episodes in the SoCAB. Summer episodes showed west to east transport with potential for pollutant carryover aloft. Forecasting methods for transport from the SoCAB to other air basins, or between other southern California basins, are more problematic and additional work will be needed to improve forecasting procedures.

Green *et al.* (1992a) classified wind field patterns in the SoCAB, San Joaquin Valley, and Mojave Desert during 1984 and 1985 to evaluate visibility reduction in the desert. This analysis evaluated transport between the SoCAB and the Mojave and Arizona deserts. Winds were found to be directly related to the pressure field, which, in summer, resulted from a consistent mesoscale component added to a varying synoptic-scale component. Three main summer patterns were found, all of which had some transport into the SEDAB from the SoCAB. The first, and predominant, pattern indicated typical summer conditions with the wind field driven by the ocean/interior temperature difference and terrain features. The second pattern typically occurred in early summer (May-early June), and had stronger flow into the desert due to synoptic-scale pressure gradients (upper level low pressure over the west coast, surface low over the Intermountain region). This type was also less stable due to cold air aloft. The third pattern showed weaker flow into the desert (and flow from the SEDAB to the SoCAB for a few hours per day) due to higher pressure to the northeast.

The predominant surface wind climatologies for California have been compiled for ARB by Hayes *et al.* (1984) based on 1977-1981 wind data. Figure 2-3 (after Hayes *et al.*) shows seven types of wind flow patterns for the SoCAB and the surrounding air basins. Not shown is an eighth possible condition of essentially calm winds. Table 2-4 gives the frequency of occurrence, expressed as a percentage, of each of these eight wind-pattern types for four times daily during each season. It should be noted that for certain times of day, particularly during the summer, southeast winds may be the predominant wind near and within the inversion (Lea *et al*, 1995; Fisk, 1996a, 1996b).

During summer (June-August) and fall (September-November), the Calm (Type VII), Offshore (Type III), and Downslope/Transitional (Type V) patterns dominate the early morning hours, allowing pollutants to accumulate in SoCAB industrial and business areas. Pollutants then move inland with the Sea Breeze (Type II) in the afternoon hours. However, a period of southeast flow towards Ventura County can occur as the land breeze veers to a daytime sea breeze. While this diurnal sequence is most common during the ozone season, other combinations of wind patterns occur that drive interbasin transport. For example, off-shore surface transport from the SoCAB to San Diego may occur with the Offshore winds (Type III), the Downslope/Transitional winds (Type V), and/or the Weak Santa Ana winds (Type VIa).

2.3 Study Period and Intensive Operational Periods

The SCOS97 field measurement program was conducted during a four-month period from June 16, 1997 to October 15, 1997. This study period corresponds to the majority of elevated ozone levels observed in southern California during previous years. Continuous surface and upper air meteorological and air quality measurements were made hourly throughout this study period. The PAMS monitoring program, which typically operates annually from July 1 to September 30, operated from June 1 to October 31, 1997.

2.3.1 Ozone Periods

Additional measurements were made during intensive operational periods (IOPs) on a forecast basis for two to four consecutive days. Forecasts were prepared each day during the four-month period and IOP measurement groups were on standby. Five categories of meteorological conditions, called scenarios, were defined and are associated with ozone episodes and ozone transport in southern California. Intensive measurements were made during these scenarios. The five scenarios in order of priority as specified by the SCOS97-NARSTO Technical Committee are:

Type 1. *SoCAB Ozone Maximum.* SoCAB pollutants remain trapped within SoCAB. There may be "local" exceedance days for other basins. This condition may be accompanied by a "coast hugger," a near-coast flow of SoCAB pollutants toward the southeast.

Type 2. *Upper-level transport to San Diego Air Basin* Ozone in a layer 300-500 m MSL above the marine layer or above the nocturnal inversion jets southeast toward San Diego. The centerline and width of this pathway are uncertain, and may range from the Interstate 15 route (east) to an off-shore route (west)

Type 3. *Secondary SoCAB Maximum.* An on-shore breeze causes inland transport, with likely transport into the Mojave Desert. This situation may also correspond to local exceedances for Ventura, Santa Barbara, and San Diego Counties.

Type 4. *Coastal Day with Eddy.* This is an extended SoCAB episode that ends with a southeast wind offshore, over the basin, and even sometimes in the desert. It is possibly an extension of Scenario #1 or #2. The ozone peaks are often seen at Newhall or Simi Valley on these days.

Type 5. *Off-shore surface transport direct to the San Diego Air Basin.* This event is characterized by a mild Santa Ana wind condition followed by the on-shore flow. It occurs with greatest frequency later in the ozone season (September-October).

The five meteorological scenarios of interest fall within three overlapping periods which together span the entire ozone season. Types 1, 2, and 3 can occur throughout the summer, but have the highest probability of occurrence in mid-summer. Type 4 typically occurs during the late spring to early summer, while Type 5 occurs from late summer to early fall.

Figure 2-3 South Coast Air Flow Pattern Types

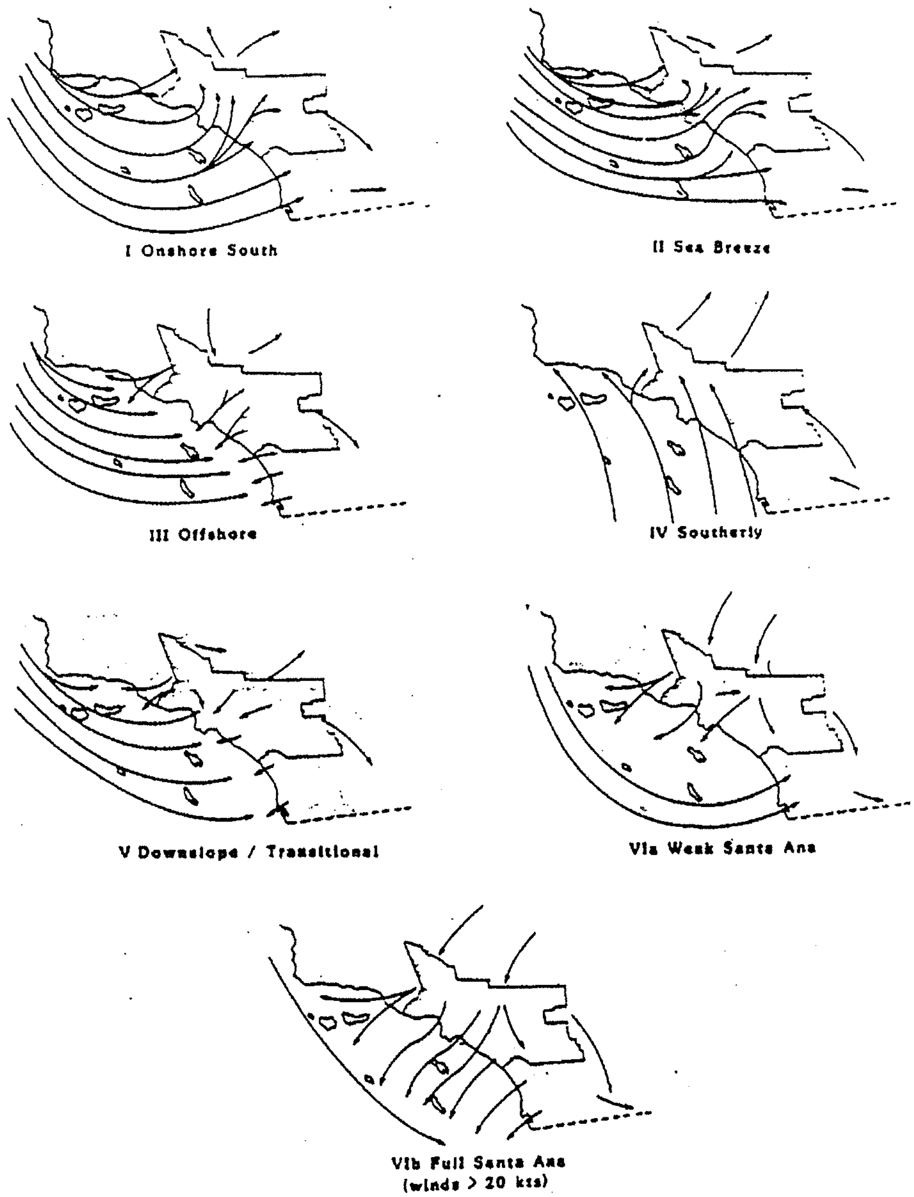

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Table 2-4
South Coast Air Basin Airflow Types
Seasonal and Diurnal Percentages of Occurrence (1977-1981 Data)

Types Time - PST	I On-Shore South	II Sea Breeze	III Off-shore	IV Southerly	V Downslope/ Transitional	VIa Weak Santa Ana	VIb Full Santa Ana (>20 kts)	VII Calm
Winter								
4 a.m.	3	3	25	3	17	10	7	29
10 a.m.	10	9	16	15	16	12	7	13
4 p.m.	24	51	4	11	4	4	2	0
10 p.m.	6	7	19	7	20	11	7	23
all times	11	18	16	9	14	9	6	16
Spring								
4 a.m.	10	8	19	6	26	4	3	24
10 a.m.	43	29	3	12	5	2	1	2
4 p.m.	31	61	2	4	1	1	1	*
10 p.m.	23	26	9	4	23	3	1	10
all times	27	31	8	6	14	3	2	9
Summer								
4 a.m.	10	5	4	4	34	1	1	37
10 a.m.	51	41	1	6	1	*	*	0
4 p.m.	26	73	0	1	0	0	0	0
10 p.m.	34	39	2	2	18	1	*	5
all times	30	40	2	3	13	1	*	11
Fall								
4 a.m.	7	10	16	2	26	7	4	25
10 a.m.	33	29	5	6	10	6	4	7
4 p.m.	20	67	4	2	2	1	1	4
10 p.m.	16	19	13	2	27	5	3	15
all times	19	31	10	3	16	5	3	13
Yearly								
4 a.m.	8	7	16	4	26	6	4	29
10 a.m.	34	27	6	10	8	5	3	6
4 p.m.	25	63	3	5	2	2	1	1
10 p.m.	20	23	11	4	22	5	3	14
all times	22	30	9	6	14	4	3	12

* < 0.5 percent

2.3.2 Aerosol Periods

The goals of the SCOS97-NARSTO Aerosol Program and Radiation Study were to develop a three-dimensional picture of the generation and evolution of typical late summer and early fall aerosols in the SoCAB, and to provide observations to support modeling of the emissions, meteorological transport and dispersion, and photochemical reactions forming ozone, PM2.5, and PM10. The experimental design focused on ambient sampling along two trajectories in southern California and a motor vehicle particle experiment to test emissions using California fuels, conducted in a tunnel in northern California:

I. A general urban aerosol generation and evolution "trajectory" began in the emissions-rich central Los Angeles area, going to a mid-trajectory site in the San Gabriel Valley, and ending in Riverside.

II. A nitrate dynamics trajectory was run from Diamond Bar, downwind of the most heavily populated portions of the Los Angeles coastal plain, across the ammonia-rich dairying area in the Chino Basin, and ending in Riverside.

III. A sampling program at the Caldecott Tunnel in northern California to measure fine particle size distributions and chemistry to develop source profiles to discriminate between emissions from light-duty (primarily gasoline-fueled) and heavy-duty (mainly diesel-fueled) vehicles.

The SCOS97-NARSTO Aerosol Program and Radiation Study consisted of six interconnected studies: a Trajectory Study, a Tunnel Study, a Fine Particle Measurement Study, a PM2.5 Federal Reference Method Nitrate Loss Study, a Radiation Study, and an Aerosol Aircraft Study. Study dates were generally from August 16 to September 29, 1997 (see Figure 2.3.2-1), with any differences noted below.

Trajectory Study

The Trajectory Study collected continuous aerosol size distribution and composition data simultaneously at three sites. These data will provide the basis for subsequent work to develop, evaluate, and improve photochemical models to simulate the chemical and physical transformations that occur as particles age and travel in the atmosphere. While many of the measurements were made over the entire 6-week period (August 16 to September 29, 1997) of the study, the full suite of sampling was conducted over five 48-hour intensive operational periods (IOPs) selected on the basis of meteorological and air quality forecasts.

The first set of measurements was made at Los Angeles-North Main, Azusa, and Riverside-Pierce Hall, corresponding to a motor vehicle-dominated west-to-east air trajectory along almost the entire length of the SoCAB. Several novel instruments operated continuously for the two-week duration: ATOFMS single-particle analysis and particle size distribution measurements by optical counters and electrical mobility at all three sites, and continuous aerosol nitrate measurements at Riverside-AgOps. Filter-based sampling was conducted during the IOPs (August 21-22, August 26-27) to calibrate the ATOFMS instruments with atmospheric particles and to give further detail on aerosol size and composition. At all three sites, PM2.5 and PM10 composition were measured with 4- to 7-hour-average filter samples for the entire 48-hour period. Micro-orifice impactor samples were collected over one 4-hour period each day at all three sites to determine particle composition in six size ranges from 0.056 to 1.8 μm.

The second set of measurements (September 4-5, September 28-29, October 31-November 1) were conducted at Diamond Bar, Mira Loma, and Riverside-Pierce Hall to focus on nitrate formation along the trajectory.

Tunnel Study

A successful data analysis and modeling effort using the database collected during the Trajectory Study depends on the acquisition of detailed emission source profiles for gasoline- and diesel-fueled motor vehicles. The Caldecott Tunnel east of Oakland is uniquely configured with a center bore only open to passenger vehicles and side bores where trucks are shunted. Thus, the particulate matter concentrations in the center bore are dominated by light-duty gasoline vehicles, and the aerosol burden in the side bores are primarily due to emissions from heavy-duty diesel trucks. During the period November 17 through 21, four experiments were conducted at Caldecott Tunnel

Fine Particle Study

The EPRI-sponsored Fine Particle Measurement Study was conducted at Riverside-AgOps from August 16 to September 22, 1997. Both continuous and 24-hour-average samplers were deployed for the study, with duplicate side-by-side samplers installed when possible. Daily sample changes were made at 10:00 a.m. Pacific Daylight Time (PDT). The continuous aerosol nitrate monitor was operated at Riverside-AgOps during the first two weeks, after which time it was moved to the Mira Loma site.

Comparison of mass and chemical data from continuous samplers (where loss of labile substances is believed minimal) with data from the more conventional filter-based methods (where losses may occur during or after sampling) will begin to characterize the magnitude of measurement error due to loss of labile substances.

PM2.5 Federal Reference Method Nitrate Loss Study

The PM2.5 FRM Nitrate Loss Study was conducted in conjunction with the Trajectory Study. Two FRM samplers were operated side by side at each of the three Trajectory Study sites for the first four experiments. Daily sample changes were made at 1:00 a.m. PDT.

Radiation Study

To test the study design and instrument operation, intensive measurements were initially made on June 29 to July 5, but data recovery at the Mt. Wilson site was incomplete due to logistical and exposure problems. The study began collecting complete data on August 21 when equipment at a new Mt. Wilson site became fully operational. Intensive monitoring on August 27-28 and September 4-6, 10, and 12 was supported by the highly instrumented Pelican aircraft, described in the following section, which provided vertical profiles of irradiance and aerosol size and concentration. Intensive radiation measurements were also made, but without the support of the Pelican, on August 21-23 and October 30-November 1.

Aerosol Aircraft Study

For aerosol and radiation measurements aloft, the Pelican aircraft was operated by the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS), a consortium of the Office of Naval Research, the Naval Postgraduate School, the California Institute of Technology, and Princeton University. Between August 27 and September 13, CIRPAS obtained measurements of the concentrations and size distributions of particulate matter and its constituent chemical species.

A display of the daily maximum 1-hour PM10 [measured with tapered element oscillating microbalance (TEOM)] and ozone concentrations recorded at Riverside-AgOps during continuous and intensive operational periods for the SCOS97-NARSTO Aerosol Program and Radiation Study is given in Figure 2.3.2-1. PM10 concentrations could be much higher than shown because the TEOM is heated to between 30 and 50 ^{o}C to eliminate humidity effects and a substantial fraction of ambient particles can be semi-volatile material such as aerosol nitrate and some organic compounds. It is interesting to note that two of the highest PM10 periods during the study occurred after hurricanes off the coast of Mexico brought large amounts of moisture to the SoCAB. A likely explanation is that formation of aerosol nitrate from gas-phase ammonia and nitric acid was favored under the high relative humidity conditions.

A statistical summary of the 24-hour-average ozone and PM10, and the average of maximum 1-hour concentrations, between August 15 and September 30 of 1995 to 1997, is presented in Table 2.3.2-1. Ozone and PM10 concentrations were about 20% lower in 1997 than the same time period in 1995. This apparent decline could be due to the introduction of California Phase 2 reformulated gasoline in 1996 or meteorological variability. Increased frequency of positive vorticity advection and mid-atmospheric troughing just west of the Pacific Coast (associated with El Niño activity) seemed to contribute to a deeper marine layer and better mixing over the SoCAB during the summer and early fall of 1997.

Preliminary analysis of the data taken at Riverside-AgOps during August 15 and September 30, 1997 show that the PM10 concentrations exhibited an afternoon peak coincident to the ozone peak. Figure 2.3.2-2 illustrates this point for August 22, 1997 with hourly PM10, ozone, and NO_x concentrations. Both PM10 and NO_x exhibited a pronounced morning peak concurrent with low ozone concentrations. The automated nitrate monitor revealed a double peak in the daily nitrate concentration profiles at Riverside. Nitrate concentrations generally increased in the midmorning hours, decreased around noon, and rose again in the afternoon. The relative magnitude of these two peaks varied from day to day.

Table 2.3.2-1. Ozone and TEOM PM10 concentrations, averaged for the time period from August 15 to September 30 for each year (1995, 1996, and 1997) at Riverside-AgOps.

Year	Ozone (ppb)		TEOM PM10 (µg/m^3)	
	24-hour average	1-hour daily maximum	24-hour average	1-hour daily maximum
1995	42	118	50	101
1996	40	107	45	85
1997	34	95	38	79

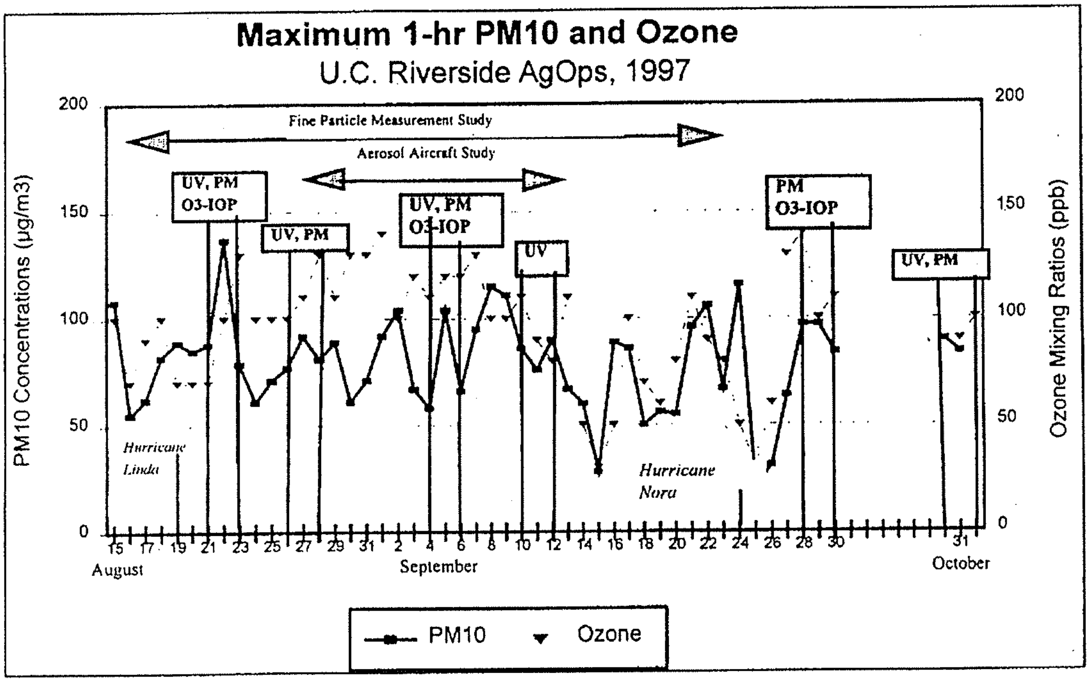

Figure 2.3.2-1. Daily maximum one-hour TEOM PM10 and ozone concentrations during the SCOS97-NARSTO Aerosol Program and Radiation Study with intensive operational periods shown for the Trajectory Study (PM), the Radiation Study (UV), and the Ozone Study (O3-IOP).

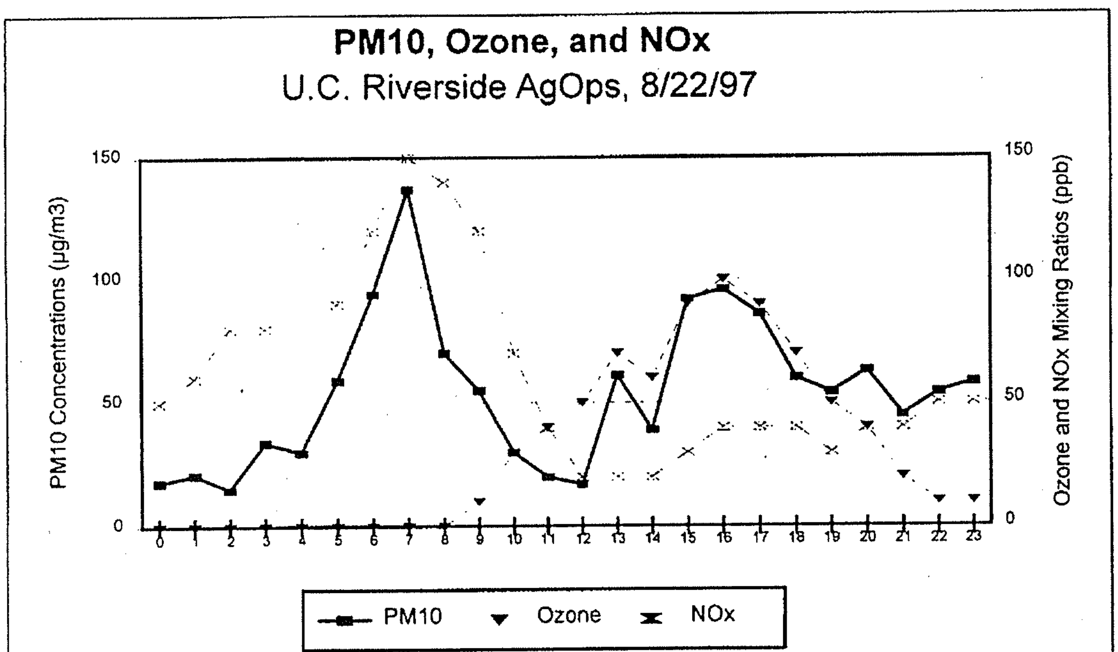

Figure 2.3.2-2. Duirnal profiles of ozone and NO_x mixing ratios at U.C. Riverside-AgOps on August 22, 1997, exhibiting an association with TEOM PM10 concentrations.

2.3.3 Tracer Study Periods

The port of Los Angeles and Long Beach are among the busiest in the world and significantly effect ambient air quality in the South Coast Air Basin. Moving the shipping channel farther off-shore has been suggested as a method to minimize the effects of ship traffic on on-shore air quality. The objective of the tracer study was to evaluate the effects on shipping emissions from moving the current shipping lanes farther from shore.

The tracer experiments were conducted when weak on-shore flows and high ozone levels were expected. These are the conditions where shipping emissions would make their largest contribution to on-shore air quality problems. During the tracer tests three ships released up to five different tracers from locations within the current and proposed shipping lanes. Up to 51 monitoring stations located through out the South Coast Air Basin measured the concentrations of the tracer gases. By comparing the releative concentrations of the five tracers an estimates of shipping emissions effects on on-shore air quality and of moving the shipping lane farther off-shore will be made.

2.4 Forecast and Decision Protocol

To ensure the goals of the SCOS97-NASTO field program were met, it was important that the appropriate air quality episodes were correctly identified. This required that a forecast team be formed to identify and forecast meteorlogical episodes which would lead to the formation of high concentrations of ozone and/or aerosol in the South Coast air basin and subsequent transport to downwind air basins. The forecast team would report their forecast to the field program management committee (FPMC). The FPMC was comprised of representatives from the Research and Technical Support Division of the California Air Resources Board (CARB), U.S. Navy at Pt. Mugu, South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD), U. S. EPA, and Ventura County Air Pollution Control District (VCAPCD). The FPMC would then decide by consensus whether an IOP would be called and notify the field study participants by email, internet home page, and telephone bill board.

2.4.1 Forecast and Decision Protocol - Ozone Periods

The forecast team was comprised of meteorologists from the California Air Resources Board (CARB), U.S. Navy at Pt. Mugu, South Coast Air Quality Management District (SCAQMD), San Diego Air Pollution Control District (SDAPCD) and Ventura County Air Pollution Control District (VCAPCD). A two-day minimum notification lead prior to an IOP was needed for equipment preparation and to allow participants to make travel arrangements to Southern California. A day-in-advance confirmation of the predicted meteorological profile and expected ozone was required before the IOP was launched. To meet these needs, the forecast was required to provide a detailed prediction of the same-day, day-in-advance and two-day expected ozone and meteorological profile for Southern California. In addition, each forecast included a three-day prediction to indicate the direction of the ozone trend (either up, down, or continuing) to provide the management team with an estimation of the likeliness of an extended IOP.

The FPMC was required to make a Go/No Go decision by 4:00 p.m. PDT daily. To meet the FPMC's needs the forecast needed to be prepared by 3:00 p.m. A 2:30 p.m. PDT daily conference call was scheduled to bring together the forecast team to finalize the forecast. The 2:30 PDT forecast time was selected to provide the individual forecast teams with access to the evolving ozone trend and the latest output from the 0500 PDT (1200 UTC) National Weather Service (NWS) numerical model simulations. The forecast discussion was conducted in three phases: (1) weather discussion and preliminary forecast, (2) group discussion and consensus forecast modification, and (3) extended outlook. Prior to the discussion, a preliminary forecast based on the SCAQMD objective model was faxed to each of the forecast groups along with an initial forecast summary. The forecast team members held discussion until a consensus was reached or a failure to agree was logged. The decision was then finalized and relayed to the FPMC.

The FPMC would then reach a consensus on whether to call an IOP. The IOP decision announcements were as follows:

- **"Possible-Go"** (or "No-Go") would be posted by 4 p.m. for an IOP start 35 hours later.

- **"Definite-Go"** (or "No-Go") would be posted by 11 a.m. for an IOP start the next morning at 0300 (midnight for the SCAQMD) for speciated VOC sampling and 0500 for rawinsondes. Under some, hopefully rare, circumstances the "Definite-Go" decision would be postponed until 4 p.m. that day, in which case the 11 a.m. posting would be for a "Possible-go".

- **After an IOP has started**, the second, third, and fourth days are automatically "Possible-Go". "Definite-Go" or "No-Go" decisions for each successive IOP day would be posted at 11 a.m. the day before, with the possibility that the decision would be postponed to 4 p.m.

- **Once a "No-Go" decision is posted, it will not be changed.** A "Definite-Go" decision would only be changed if the predicted meterological situation totally collapsed. In this case, each measurement group would be notified individually.

2.4.2 Forecast and Decision Protocol - Aerosol Periods

Over the entire 6-weeks period (August 16 to September 29, 1997) the trajectory study, aircraft study, and FRM nitrate loss study relied on forecasts from the SCAQMD for selecting the best two days (PM episode) of the upcoming week for intensive sampling.

In general typical meteorological characteristics of a high PM10 day in the SoCAB include: a well developed upper-level ridge of high pressure, strong elevated subsidence inversions, low level stratus and fog, and a nearly neutral surface and boundary layer wind field. However, increased frequency of positive vorticity advection and mid-atmospheric troughing just west of the Pacific Coast (associated with El Niño activity) seemed to contribute to a deeper marine layer and better mixing over the SoCAB during the summer and early fall of 1997.

Two consecutive days of measurements were made each week, chosen in consultation among Professors Glen Cass and John Seinfeld of Caltech, Joe Cassmassi of SCAQMD, professor Kim Prather of U.C. Riverside, Dr. Susanne Hering of ADI, and Mr. Tony VanCuren of ARB.

"Go" Decision Protocol and Announcements

- Each day, by 3 PM, the group made a "No-Go" or "Probable-Go" decision for aerosol measurements commencing in 34 hours. Once a "No-Go" decision was made, it could not be changed.
- If the following day was a "Probable-Go", the group made a final "No-Go" or "Definite-Go" decision for aerosol measurements by 11 AM.
- Each day, by 3 PM, the ARB posted the decision on the phone machine and with an e-mail message.
- The 2-day IOPs were at least 2 days apart.
- The preference was to have at least one 2-day IOP each week.
- Intensive sampling periods could occur on a weekend, if it was the time period of high PM concentrations.

2.5 Summary of Ozone Intensive Operational Periods

Six Intensive Operational Periods (IOPs) were called during the 1997 Southern California Ozone Study which was conducted in coordination with the North American Research Strategy for Tropospheric Ozone (SCOS97-NARSTO). The first IOP was cut short (lasted only one day) due to the unanticipated high clouds from a hurricane south of the study area. Three other IOPs had partial deployment of resources on the day before or after the IOP to better characterize the full ozone episode. A summary of the IOPs, Table 2.5a, provides information on the dates, day-of-week, type of episode, maximum 1-hour and 8-hour ozone concentrations by sub-areas, aircraft activities, and concurrent aerosol or tracer release activities. The air quality concentrations noted are based on preliminary data and are subject to change. Intensive Operational Days for aerosols occurred on five ozone intensive days during three ozone IOPs. The three offshore tracer releases also occurred during three ozone intensive days. Exceedances of the national ambient air quality standards for ozone occurred during all six episodes.

To provide the context of the IOPs during SCOS97-NARSTO, Table 2.5b and Figures 2.5a-f are included in this summary. The Table and Figure provide the daily maximum 1-hour and 8-hour ozone concentrations observed in each air basin within the SCOS97-NARSTO modeling domain from June 15 through October 16, 1997. These summaries are based on data residing on the U.S. EPA's Aerometric Information and Retrieval System (AIRS) on March 26, 1998. It is noteworthy that the ozone episodes that occurred during the long Independence Day weekend had among the highest, if not the highest, 1-hour and 8-hour ozone concentrations for the study period.

The following subsections briefly describe the meteorological and air quality conditions observed during each of the IOPs. In principle, the following non-routine measurements were made during each day of an IOP:

1) four 3-hour samples each of volatile organic compounds (VOC) and carbonyl compounds (C=O) at 18 sites (two 12-hour samples were taken at the three background/offshore sites)
2) peroxyacetyl nitrate measurements at Simi Valley and Azusa
3) lidar measurements at two sites (ozone and aerosol scatter at El Monte AP on ozone IOPs and several aerosol IOPs; ozone aerosol scatter, water vapor, and temperature near Hesperia between August 23 and September 19)
4) four ozonesonde releases (at 0800, 1400, 2000, and 0200 PDT) each day from 7 sites (Anaheim, California State University at Northridge, Pomona/Upland, Point Mugu, Riverside, University of Southern California, and Valley Center
5) four rawinsonde releases (at 0500, 1100, 1700, and 2300 PDT) each day from 12? sites (Bakersfield, China Lake Naval Air Weapons Center, Edwards AFB, Imperial Beach, Miramar Naval Air Station, North Island Naval Air Station, Pt. Mugu Naval Air Weapons Center, San Nicolas Island, Tustin, Twentynine Palms-Expeditionary Air Field, University of California at Los Angeles, and Vandenberg AFB
6) multiple flights per day by up to six aircraft
   a) Aztec - northern boundary and trans-basin in SoCAB; also back-up for Navajo
   b) Navajo - western boundary and offshore
   c) Partnavia - offshore

d) San Diego Cessna 182 - southern domain

e) UCD Cessna 182 - central SoCAB

f) Pelican - SoCAB aerosol characterization (flights coincided with ozone IOPs only on September 3-6)

Occasions when measurements did not occur as planned during an IOP are noted in discussion.

Table 2.5a List of Ozone Intensive Operational Days During SCOS97-NARSTO

		Episode	Max 1-hr/8-hr Ozone Concentrations (pphm)						Number of Flights						Other
Date#	Day	Type*	SC	VC	SD	MD	SB	IC	CP	SDC	SDN	STI	UCD	USN	IOPs+
Jul 14	Mon	1-,2-,3-	14/10.6	9/ 8.0	10/ 6.9	11/10.3	6/ 5.7	9/ 8.1	0	0	0	1[1]	2	0	
Aug 4	Mon	1-,2-,3-	14/10.5	9/ 7.7	11/ 9.9	12/ 8.1	7/ 6.0	10/ 9.3	0	2	1	2	3	0	
Aug 5	Tue	1-, 2-	19/11.9	9/ 8.1	12/ 8.7	11/10.4	10/ 8.1	10/ 9.3	0	2	2	2	3	2	
Aug 6	Wed	1-, 3, 4,5-	16/12.5	13/11.5	10/ 8.4	13/10.7	9/ 8.2	8/ 8.0	0	2	1	2	3	2	
Aug 7[2]	Thu	1-,3,4-	15/12.2	12/ 8.8	7/ 5.2	14/11.3	10/ 8.7	8/ 7.1	0	0	0	1	0	1	
Aug 22	Fri	1-,3-	13/ 9.0	9/ 7.5	8/ 6.3	10/ 9.0	7/ 5.5	12/10.0	0	2	2	2	3	2	A
Aug 23	Sat	1-,3-,4-,5-	14/10.6	10/ 8.9	10/ 7.0	11/ 9.0	7/ 5.4	8/ 7.1	0	2	2	2	3	0	T
Sep 3[3]	Wed	1-	13/ 9.0	8/ 7.4	9/ 7.3	8/ 6.6	8/ 6.0	6/ 5.2	0	0	0	1[1]	3	0	
Sep 4	Thu	1-,2	16/ 9.9	9/ 7.5	13/ 9.0	7/ 6.3	9/ 7.5	6/ 4.9	1	2	2	2	3	1	A & T
Sep 5	Fri	3-	12/ 9.1	10/ 7.2	8/ 8.8	10/ 6.9	7/ 6.8	8/ 5.8	1	2	2	2	2	2	A
Sep 6	Sat	0	12/ 9.4	9/ 7.1	8/ 5.9	8/ 7.3	6/ 4.7	7/ 5.7	1	2	2	2	2	2	
Sep 27[3]	Sat	1-,2-	14/10.2	9/ 7.5	11/ 9.6	8/ 6.4	8/ 6.8	6/ 5.9	0	1	2	0	2	1	
Sep 28	Sun	1-,2-,4-	17/10.7	12/ 9.7	11/ 9.4	6/ 6.4	11/ 9.3	6/ 5.0	0	2	2	2	2	0	A
Sep 29	Mon	4-	11/ 8.9	11/ 8.6	9/ 6.7	10/ 7.7	11/ 7.6	11/ 7.0	0	2	2	2	2	0	A
Oct 3	Fri	0	9/ 7.5	8/ 6.7	4/ 4.0	6/ 5.3	7/ 6.1	7/ 6.1	0	2	2	2	2	1	
Oct 4	Sat	3-, 4-	13/10.5	9/ 7.4	7/ 6.7	10/ 7.4	7/ 6.9	11/ 7.8	0	2	2	2	2	2	T

1 flew western boundary in afternoon
2 aircraft flights in vicinity of Ventura and Santa Barbara Counties to capture eddy transport
3 partial deployment of resources (including NOAA lidar)
dates in bold type denote full Intensive Operational Days; dates in normal type denote partial Intensive Operational Days; "-" indicates concentrations less than the study goals for that type of episode

* **Episode Types:**
- 0 No episode
- 1 South Coast Air Basin ozone maximum
- 2 Upper level transport to San Diego
- 3 Secondary South Coast Air Basin ozone maximum with transport into Mojave Desert
- 4 Eddy transport to Ventura following episode in South Coast Air Basin
- 5 Off-shore surface transport to San Diego

+ **Other IOPs:** A = aerosol; T = tracer
abbreviations: SC = South Coast Air Basin, VC = Ventura County, SD = San Diego County, MD = Mojave Desert, SB = Santa Barbara County,

aircraft: CP = CIRPAS Pelican (central/eastern SoCAB), SDC = San Diego Cessna (San Diego County), SDN = San Diego Navajo (western boundary), STI = STI Aztec (northern boundary & SoCAB transit), UCD = UCD Cessna (central SoCAB), USN = USN Partnavia (offshore)

Table 2.5b Daily Maximum Ozone Concentrations During SCOS97-NARSTO

Daily Maximum 1-hour and 8-hour Ozone Concentrations (ppb)
by Air Basin During SCOS97-NARSTO
(based on AIRS data base as of 3-26-98)
partial and full intensive operational days are indicated with shading

Date	SoCAB		MDAB		SDAB		SCCAB		SSAB		SJVAB (KC)	
1997	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr
615	95	73	73	68	62	59	66	59	95	79	79	72
616	90	79	102	80	72	63	75	68	97	80	118	92
617	120	100	111	91	84	72	88	85	130	109	129	106
618	140	116	123	102	74	61	114	97	120	89	83	67
619	136	103	126	113	86	70	100	86	105	95	101	82
620	110	81	101	89	68	58	101	84	89	79	92	85
621	114	88	105	99	82	67	77	68	80	70	74	68
622	100	82	96	85	74	61	75	66	71	65	69	66
623	95	80	107	92	71	59	75	67	85	76	75	70
624	115	99	131	118	85	66	104	92	130	111	89	80
625	137	114	125	105	72	64	112	95	130	93	104	92
626	150	105	130	112	90	71	117	95	97	77	91	79
627	144	113	127	115	82	73	99	87	100	90	86	76
628	128	106	116	94	88	81	82	75	90	86	79	69
629	84	71	81	69	84	61	86	79	80	75	66	61
630	82	68	86	77	60	50	66	56	80	79	49	46
701	118	96	105	93	94	83	70	67	100	91	84	72
702	170	139	187	133	101	90	96	91	130	109	90	78
703	205	143	177	133	112	95	115	104	160	120	124	107
704	168	138	152	129	136	112	119	112	100	88	131	113
705	151	124	119	95	120	102	128	110	98	81	99	88
706	147	123	142	120	96	84	114	105	87	80	88	73
707	115	100	117	104	78	58	89	80	100	89	105	84
708	107	101	114	103	77	63	92	86	102	83	110	95
709	124	107	124	105	87	68	104	93	104	93	114	94
710	121	99	120	103	61	56	91	78	90	90	71	62
711	89	71	80	74	69	53	67	59	80	78	77	68
712	96	85	90	82	69	58	80	73	90	84	79	72
713	130	113	115	103	73	64	94	83	108	81	103	91
714	110	90	112	103	77	67	85	75	120	100	114	98
715	95	73	93	85	98	78	73	67	110	88	107	90
716	139	112	136	109	99	83	103	84	131	101	114	90
717	119	99	108	93	88	75	70	65	111	100	83	66
718	109	91	122	97	83	57	86	74	84	73	64	60
719	107	102	111	95	61	54	85	72	91	80	103	88
720	141	125	128	108	73	61	88	80	114	58	107	94
721	106	84	88	83	58	56	104	78	68	84	123	100

Date	SoCAB		MDAB		SDAB		SCCAB		SSAB		SJVAB (KC)	
1997	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr
722	77	55	63	57	67	56	49	42	80	65	74	62
723	118	92	102	72	106	84	99	89	70	68	85	75
724	101	83	89	79	79	66	94	78	84	69	90	82
725	121	88	96	76	88	71	90	74	98	87	111	92
726	132	120	111	101	77	65	77	65	95	76	90	81
727	139	125	97	78	75	62	84	75	111	84	104	87
728	104	97	107	83	63	54	77	65	105	80	105	92
729	105	94	110	89	60	51	73	67	109	86	109	96
730	122	102	119	102	90	72	89	74	87	73	96	87
731	125	100	120	100	86	68	94	88	100	93	103	85
801	123	91	101	77	120	82	90	75	109	85	101	87
802	159	96	113	70	115	81	109	87	143	94	101	84
803	135	112	92	97	117	82	102	85	80	75	118	91
804	132	104	124	81	93	72	94	77	114	93	122	93
805	187	118	106	104	122	87	100	81	100	93	126	98
806	154	118	131	107	103	84	134	115	80	80	141	119
807	150	114	141	113	69	52	116	88	87	74	146	118
808	136	121	128	105	81	61	89	74	91	74	130	105
809	105	94	98	84	65	46	78	61	70	70	100	83
810	84	73	77	67	47	40	51	43	80	73	77	64
811	92	79	85	74	54	45	60	52	92	75	81	71
812	112	99	92	86	69	60	89	66	100	81	120	95
813	129	102	129	97	79	64	85	76	90	81	112	97
814	138	118	102	103	80	65	95	76	116	99	118	96
815	141	119	135	104	73	54	84	67	102	95	125	100
816	109	94	94	79	65	53	63	54	90	80	97	82
817	102	80	94	77	76	61	76	62	70	70	84	75
818	101	80	96	76	77	60	91	73	90	81	102	87
819	75	56	87	75	87	57	66	52	80	80	86	67
820	77	60	79	67	49	38	55	44	80	74	80	73
821	112	72	98	81	63	46	57	48	80	79	100	81
822	133	90	108	90	79	63	86	75	124	100	119	95
823	139	105	114	90	96	70	102	89	83	73	102	78
824	123	101	103	77	76	63	100	77	100	86	83	64
825	103	89	96	81	66	57	79	66	90	76	97	81
826	112	99	93	80	76	65	90	77	100	77	93	79
827	116	96	125	94	103	81	87	83	96	66	89	71
828	132	104	123	90	85	64	92	81	67	62	83	71
829	110	82	87	78	82	62	108	93	85	64	83	70
830	137	100	104	75	89	68	113	100	86	66	104	90
831	153	124	91	83	87	72	116	100	65	60	99	80
901	149	115	124	87	94	69	104	92	69	54	114	92

Date	SoCAB		MDAB		SDAB		SCCAB		SSAB		SJVAB (KC)	
1997	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr
902	97	69	82	62	76	53	112	93	54	49	74	62
903	125	90	82	66	83	73	80	74	60	52	134	106
904	157	99	73	63	94	77	86	75	60	52	110	90
905	113	91	97	69	80	71	95	72	81	58	102	80
906	118	92	82	64	76	59	88	71	67	57	93	73
907	131	96	71	64	75	62	90	68	88	65	90	77
908	100	75	82	73	84	70	80	72	70	56	105	86
909	105	79	111	81	95	65	97	80	58	52	110	87
910	113	83	94	81	73	59	78	68	90	73	88	73
911	96	69	80	67	59	50	96	70	62	54	64	56
912	83	65	95	82	72	59	92	74	69	59	99	82
913	104	77	90	72	90	73	80	73	70	59	92	82
914	107	84	72	60	111	89	96	86	47	38	84	66
915	74	54	54	51	62	43	88	73	74	37	63	50
916	63	49	62	55	68	52	74	63	46	37	60	55
917	92	69	89	69	101	71	74	65	90	63	87	74
918	76	53	76	70	80	56	88	73	61	45	95	70
919	54	43	60	56	77	50	54	51	54	42	61	55
920	88	68	70	61	62	46	77	66	59	48	85	72
921	104	76	67	61	78	65	87	72	92	65	80	75
922	94	74	62	57	91	76	101	88	70	60	107	91
923	113	88	59	55	93	71	137	108	156	92	98	89
924	61	56	56	54	81	72	89	80	57	46	70	56
925	36	34	41	41	52	31	67	65	50	39	46	43
926	51	44	79	72	53	48	78	67	69	60	73	65
927	138	92	77	63	88	75	86	75	60	59	78	65
928	171	107	58	54	105	84	118	97	63	58	109	90
929	112	87	97	77	86	67	114	86	110	70	84	73
930	107	84	81	76	82	66	96	77	78	65	94	78
1001	129	103	120	91	70	58	106	89	110	82	102	90
1002	68	60	59	51	47	45	77	63	100	65	46	35
1003	92	75	60	53	44	40	80	67	70	61	65	59
1004	123	95	102	74	71	67	85	74	110	78	94	83
1005	119	105	124	114	95	73	81	69	120	88	90	79
1006	93	86	85	70	71	68	71	54	65	64	60	50
1007	46	46	52	48	50	48	48	47	50	45	40	36
1008	59	53	60	55	65	53	62	60	61	55	53	48
1009	82	65	72	64	77	67	70	62	68	61	65	60
1010	60	41	58	51	59	47	49	46	100	63	44	41
1011	53	39	48	45	49	46	47	45	50	50	38	33
1012	52	49	48	46	59	52	54	50	50	42	46	41
1013	51	49	51	48	56	46	62	58	50	45	55	45

Date	SoCAB		MDAB		SDAB		SCCAB		SSAB		SJVAB (KC)	
1997	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr	1-hr	8-hr
1014	60	47	50	46	56	44	74	63	50	43	55	47
1015	53	43	49	46	71	54	65	58	51	43	72	58
1016	58	50	57	49	63	45	72	63	90	44	76	57

SoCAB = South Coast Air Basin; **MDAB** = Mojave Desert Air Basin; **SDAB** = San Diego Air Basin; **SCCAB** = South Central Coast Air Basin; **SSAB** = Salton Sea Air Basin; **SJVAB (KC)** = Kern County portion of San Joaquin Valley Air Basin

2.5.1 Synopsis of the July 14, 1997 Intensive Operational Period

The first IOP of the SCOS97-NARSTO occurred on Monday, July 14. When the forecast team decided that conditions conducive to the formation of high ozone concentrations on July 15 were not developing as anticipated, the IOP was terminated. Although the IOP was not of sufficient duration for modeling purposes, this IOP served as a valuable "shakedown" exercise for identifying and correcting potential problems before additional IOPs were called.

The preliminary peak 1-hour ozone concentration during this IOP was 14 pphm (the peak on July 15 was 12 pphm). Except for the high ozone concentrations observed during the July 2-6 Independence Day weekend (when a "Stand down" was in effect due to large forest fires in the San Gabriel Mountains and atypical traffic patterns expected during the long holiday weekend), the peak ozone concentration observed during the IOP was the highest until then during the month of July. Maximum 8-hour concentrations were relatively low although the national standard was exceeded in the South Coast, Mojave Desert, and Salton Sea Air Basins. This one-day IOP captured three weak episode types of interest to the study sponsors but resources were held in reserve in anticipation of future episodes with greater potential for high ozone concentrations.

Day 1

Although a high atmospheric pressure system was building in the "Four Corners" region on Monday, July 14, ozone concentrations did not rise as much as forecast due to the influence of high clouds from hurricanes off Baja California and a weak low pressure system off the central coast of California. Only the STI and UCD aircraft flew on this day. The STI Aztec flew the western boundary and offshore route only during the afternoon due to extensive fog during the morning. The influence of the cloud cover and offshore low pressure system further limited ozone production to a peak concentration of 12 pphm on July 15.

2.5.2 Synopsis of the August 4 - 7, 1997 Intensive Operational Period

The first full IOP of the SCOS97-NARSTO occurred from Monday, August 4 into Thursday, August 7. The preliminary peak 1-hour ozone concentration during this IOP was 19 pphm at Riverside. That ozone concentration is the second highest observed during SCOS97-NARSTO (the highest concentration occurred in conjunction with the Independence Day weekend). In addition, this three-day plus episode captured weak versions of all five episode types of special interest to the study planners. High surface temperatures actually may have reduced the peak concentrations by creating a much larger vertical mixing volume than otherwise would have occurred. Although the region of extremely high ozone concentrations was somewhat limited on the peak (second) day of the episode, several sites and areas exceeded the national ambient air quality standard (NAAQS) on the third day of the episode. Despite extremely hot surface temperatures, air conditioning failures, and power outages, the data recovery during this first multi-day IOP of SCOS97-NARSTO appears to have been quite high. Data losses occurred at a couple of radar wind profiler sites and on the morning flight of the western boundary aircraft. Most other data losses were of a short-term nature.

Day 1

On Monday, August 4, a high atmospheric pressure system was building in the "Four Corners" region. On this "ramp-up" day for photochemical modeling, ozone concentrations were highest in the eastern portion of the SoCAB, peaking at 14 pphm at Rim of the World High School and also exceeding the NAAQS at the University of California in Riverside and Banning Airport. Only Black Mountain in San Diego exceeded the California ambient air quality standard (CAAQS). The ozone lidar staff reported two layers of high ozone concentrations (at approximately 1.25 and 2.5 km); the lower layer disappeared with the hot surface temperatures breaking that inversion. Aircraft pilots reported preliminary ozone concentrations of 13 pphm in the vicinity of Temecula. Data were lost from the morning flight of the San Diego Navajo. The USN Partnavia was unavailable on this day.

Day 2

On Tuesday, August 5, 500 mb pressure heights were above 5900 meters and 850 mb temperatures were above 30 degrees C. Very hot surface temperatures were also expected and the concern was whether the temperature inversion would break before high ozone levels occurred. Peak ozone concentrations increased markedly from the previous day in the eastern SoCAB and at Otay Mesa in southern San Diego County. Peak concentrations were 19 pphm at Riverside-Rubidoux and 17 pphm at UC Riverside and Redlands. A limited number of other sites exceeded the NAAQS but with a maximum of 15 pphm. The NAAQS was not exceeded in the surrounding air basins but the CAAQS was exceeded at several sites in San Diego County (Otay Mesa being the highest at 12 pphm) and at one site in Santa Barbara. Aircraft pilots reported preliminary ozone concentrations of 18 pphm near Temecula and San Clemente Island during the morning and 19 pphm in the vicinity of Riverside during the afternoon.

Day 3

On Wednesday, August 6, widespread high ozone concentrations were forecast with a Type 1 episode giving way to episode types 3 and 4. The peak ozone concentration occurred at Rim of the World High School (16 pphm) and 15 pphm concentrations were observed at Redlands and Crestline. Several sites exceeded the NAAQS including Simi Valley in Ventura County and Hesperia in the Mojave Desert. With a coastal eddy developing, concentrations near the coast declined. However, the eddy also advected high ozone concentrations from the SoCAB into Ventura County with exceedances of the NAAQS being observed at Simi Valley and at Laguna Peak and Calabasas during the evening. With stronger on-shore flow, Hesperia, north of Cajon Pass in the Mojave Desert, also exceeded the NAAQS. The San Diego Navajo was only able to fly the western boundary/offshore route during the morning as military operations offshore and mechanical difficulties forced it to abort its afternoon flight.

Day 4

On Thursday, August 7, the coastal eddy thickened the marine layer and pushed the high ozone concentrations in the SoCAB further inland than on the previous day. The highest concentrations were 15 pphm at Lake Elsinore, 14 pphm at Hesperia, Rim of the World High School, Banning Airport, and Phelan. Because of the coastal eddy and the potential for unhealthful ozone concentrations in Ventura County, the U.S. Navy and STI aircraft were authorized to fly over Ventura County and offshore to characterize the distribution of ozone concentrations during the eddy. The departure of the aircraft was delayed by fog and significant amounts of ozone aloft were not encountered by the aircraft. A peak surface ozone concentration of 12 pphm was observed at Simi Valley.

2.5.3 Synopsis of the August 22 - 23, 1997 Intensive Operational Period

The second full IOP of SCOS97-NARSTO occurred on Friday and Saturday, August 22 and 23. The peak 1-hour ozone concentration during this IOP was 14 pphm at Riverside; the peak 8-hour concentration was 10.5 pphm at Redlands. This IOP captured several weak episodes of types 1, 3, 4, and 5. Although the potential for high ozone concentrations was limited, interest existed for capturing a weekend episode with moderate concentrations. However, cloud cover and moisture once again suppressed the peak ozone concentrations. Concentrations were slightly higher on Saturday but with lower ozone levels forecast for Sunday, the IOP was terminated.

Day 1

On Friday, August 22, ozone concentrations were highest in the sunnier northwest portion of the study area: 13 pphm in the San Fernando Valley. Interestingly, ozone concentrations at a site in Imperial County reached 12 pphm and the 8-hour average of 10.0 pphm was the highest in the study area on this day. The NAAQS was exceeded only in the South Coast Air Basin. Aircraft pilots reported ozone concentrations of 7-8 pphm aloft near San Nicolas Island and 15-17 pphm aloft over the central SoCAB. An aerosol IOP also occurred on this day.

Day 2

On Saturday, August 23, peak ozone concentrations increased modestly from the previous day in the coastal air basins. The peak concentrations was 14 pphm at Riverside-Rubidoux. The NAAQS was not exceeded in the surrounding air basins but the CAAQS was exceeded in the South Central Coast, San Diego, and Mojave Desert Air Basins. An offshore tracer release occurred on this day. The USN Partnavia was not available for operations on the second day of the IOP.

2.5.4 Synopsis of the September 3 - 6, 1997 Intensive Operational Period

Both the peak 1-hour and 8-hour ozone concentrations (16 and 9.9 pphm, respectively) during this IOP occurred on September 4 at Mt. Baldy Village. The 16 pphm ozone concentration represents the fourth highest episode observed during SCOS97-NARSTO (the July 2-4, August 5, and September 28 episodes were higher). This three-day plus episode captured the best Type 2 episode event during SCOS97-NARSTO and weak Type 1 and 3 episodes. The NAAQS was only exceeded on September 4 in the SoCAB and SDAB. This IOP also featured two intensive aerosol days and an offshore tracer release.

Day 1

On Wednesday, September 3, a partial IOP was initiated with the NOAA lidar, UCD Cessna, and STI Aztec operating. The Aztec flew the western boundary route during the afternoon while the Cessna made three flights. On this "ramp-up" day for photochemical modeling, ozone concentrations were below the CAAQS in all areas except the SoCAB. The peak 1-hour/8-hour concentrations were 13/9.0 pphm at Mt. Baldy Village in the San Gabriel Mountains.

Day 2

On Thursday, September 4, the CAAQS and the 8-hour NAAQS were only exceeded in the South Coast and San Diego Air Basins. The 1-hour and 8-hour peaks in the SoCAB on this day were also the peaks for the IOP. An aerosol IOP and a offshore tracer release were conducted on this day.

Day 3

On Friday, September 5, no areas exceeded the 1-hour NAAQS and only the SoCAB and SDAB exceeded the 8-hour NAAQS. The CAAQS was only exceeded in the South Coast, San Diego, and Mojave Desert Air Basins on this day. An aerosol IOP also occurred on this day.

Day 4

On Saturday, September 6, the only area to exceed the CAAQS or the 8-hour NAAQS was the SoCAB. Effectively, the last day of the IOP was an Episode Type 0.

2.5.5 Synopsis of the September 27 - 29, 1997 Intensive Operational Period

Both the peak 1-hour and 8-hour ozone concentrations (17 and 10.7 pphm, respectively) during this IOP occurred on September 28 at Upland. The 17 pphm ozone concentration represents the third highest episode observed during SCOS97-NARSTO (the July 2-4 and August 5 episodes were higher). The 1-hour NAAQS was exceeded only on September 27 and 28 in the SoCAB but the CAAQS was exceeded in all areas and the 8-hour NAAQS was exceeded in all areas except the Mojave Desert Air Basin and Imperial County. This IOP also featured intensive aerosol days on the 28^{th} and 29^{th}.

Day 1

On Saturday, September 27, a partial IOP was initiated with the NOAA lidar, UCD Cessna, US Navy Partnavia, and both San Diego aircraft operating. On this potential "ramp-up" day for photochemical modeling, ozone concentrations were above the NAAQS only in the SoCAB and above the CAAQS in the SDAB. The SoCAB and SDAB were also the only air basins where the 8-hour NAAQS was exceeded.

Day 2

The peak 1-hour and 8-hour ozone concentrations during this IOP occurred on Sunday, September 28, 17 and 10.7 pphm, respectively in the SoCAB. The CAAQS and the 8-hour NAAQS were also exceeded in San Diego, Ventura, and Santa Barbara Counties. An aerosol IOP occurred on this day

Day 3

On Monday, September 29, no areas exceeded the 1-hour NAAQS and only the SDAB did not exceeded the CAAQS. The 8-hour NAAQS was only exceeded in the SoCAB and Ventura County on this day. An aerosol IOP also occurred on this day.

2.5.6 Synopsis of the October 3 - 4, 1997 Intensive Operational Period

The last IOP of the SCOS97-NARSTO occurred Friday and Saturday, October 3 and 4. The peak 1-hour ozone concentration during this IOP was only 13 pphm at Rim of the World High School; the peak 8-hour concentration was a relatively high 10.5 pphm, also at Rim of the World High School. The CAAQS was also exceeded in the MDAB and Imperial County. The MDAB was the only area besides the SoCAB to exceed the 8-hour NAAQS. A tracer material was released offshore in the shipping lanes on Saturday, October 4. Both 1-hour and 8-hour ozone concentrations increased significantly in almost all areas from October 3rd to the 4th

2.6 Recommendations of Which IOPs to Model

2.6.1 Recommendations of Which Ozone IOPs to Model

Although ozone concentrations were less than hoped for or even expected during the SCOS97-NARSTO due to the persistent passage of low pressure systems associated with the well-publicized El Niño, the episodes with the highest possible 1-hour concentrations were captured. Valuable insights and information will be gleaned from modeling applications. Four of the six IOPs have reasonable justifications for being modeled. Listed below, in order of priority, are the episodes recommended for potential modeling; pertinent information is also included.

A) August 4 - 7
   1) peak ozone concentration during IOPs (19 pphm)
   2) several episode types occurred
   3) exceedances of CAAQS in all six areas; exceedances of NAAQS in three areas

B) September 3 - 6
   1) concurrent with aerosol IOP and tracer release
   2) concentrations relatively low although SoCAB peak is 16 pphm

C) September 27 - 29
   1) IOP with second highest ozone concentration (17 pphm)
   2) concurrent with aerosol IOP

D) October 3 - 4
   1) low ozone concentrations but relatively large increase from one day to the next in most areas
   2) tracer release occurred on second day

2.6.2 Recommendations of Which Aerosol IOPs to Model

Between August 27 and September 13, Caltech and CIRPAS obtained aircraft measurements of the concentrations and size distributions of particulate matter and its constituent chemical species. The information obtained from aircraft observations of the vertical distribution of gas- and aerosol-phase chemical species will further improve the understanding of the dynamics of particulate air pollution in the SoCAB. It will also be used for testing, diagnosis, and improvement of mathematical models used in assessing the impacts of proposed emission control strategies.

The following is a list of the dates from the SCOS97 aerosol monitoring program, recommended for potential aerosol modeling in the SoCAB. These dates are recommended because the most extensive aerometric data sets are available from advanced continuous (such as ATOFMS single-particle analysis and particle size distribution measurements by optical counters and electrical mobility) and filter-based aerosol measurement equipment at surface sites, an array of solar radiometers, and an aircraft instrumented with advanced aerosol analyzers.

August 26 - August 28
- Aircraft sampling supported the three-dimensional evolution of aerosol size and concentration along the same west-to-east path as the first set of Trajectory Study experiments.

September 4 - 6
- Aircraft sampling supported the "nitrate trajectory" sampling with measurements both along the transport path and over a wider area to help characterize the spatial extent of phenomena observed along the trajectory.

September 9 - 13
- Aircraft sampling provided vertical profiles of irradiance and aerosol size and concentration for the Intensive radiation measurements.

September 27 - September 28
- The nitrate peak was about 40 μg/m3, concurrent with ozone IOP (IOP with second highest ozone concentration of 17 pphm in SoCAB).